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Impact of ocean resolution and initialisation in climate seasonal predictions

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SPECS
Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

BSC Earth Sciences Department

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What

Environmental modelling and forecasting

Why

Our strength …
- … research …
- … operations …
- … services …
- … high resolution …

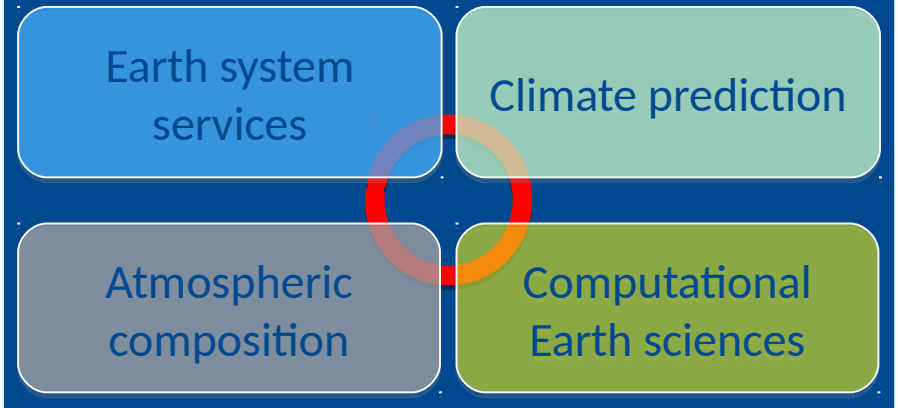
How

Develop a capability to model air quality processes from urban to global and the impacts on weather, health and ecosystems

Implement climate prediction system for subseasonal-to-decadal climate prediction

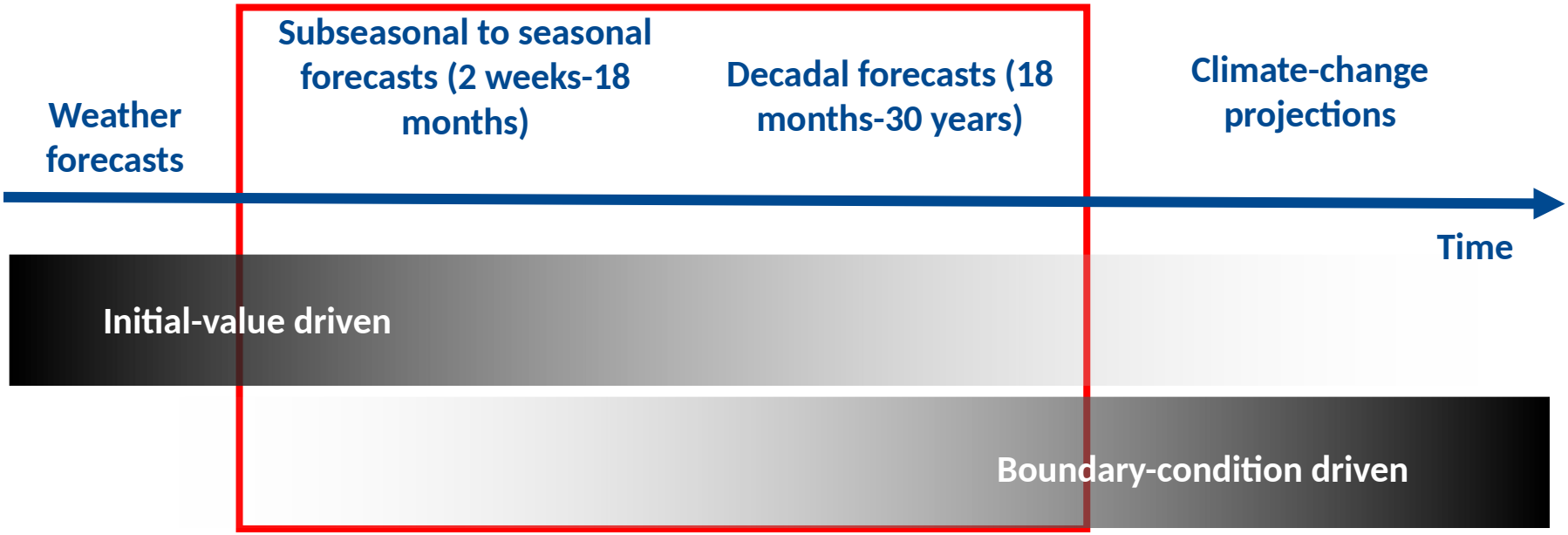
Develop user-oriented services that favour both technology transfer and adaptation

Use cutting-edge HPC and Big Data technologies for the efficiency and user-friendliness of Earth system models



Climate prediction time scales

Between initial-value problems (weather forecasting) and multi-decadal to century projections as a forced boundary condition problem.

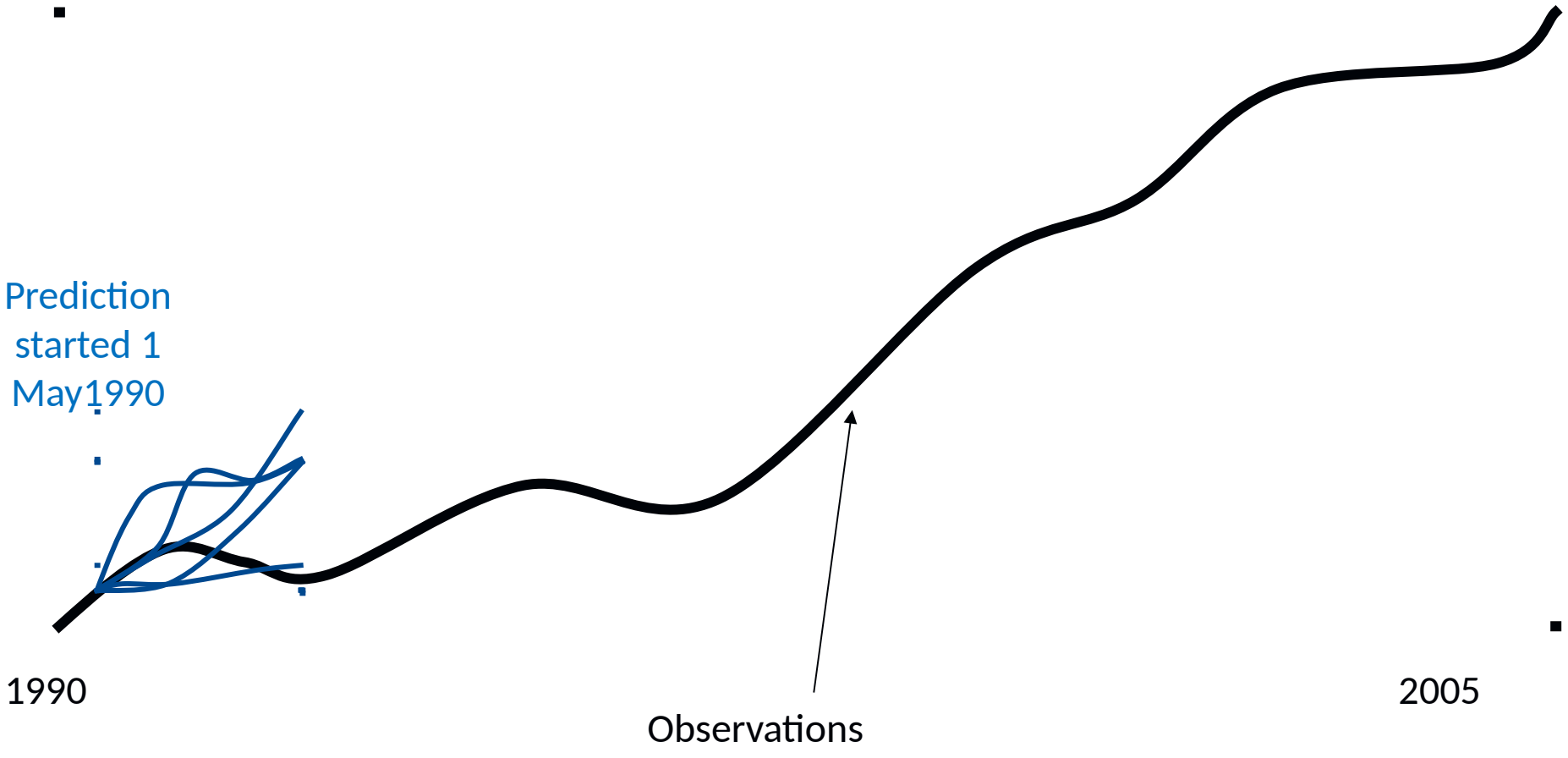


Adapted from Meehl et al. (2009)

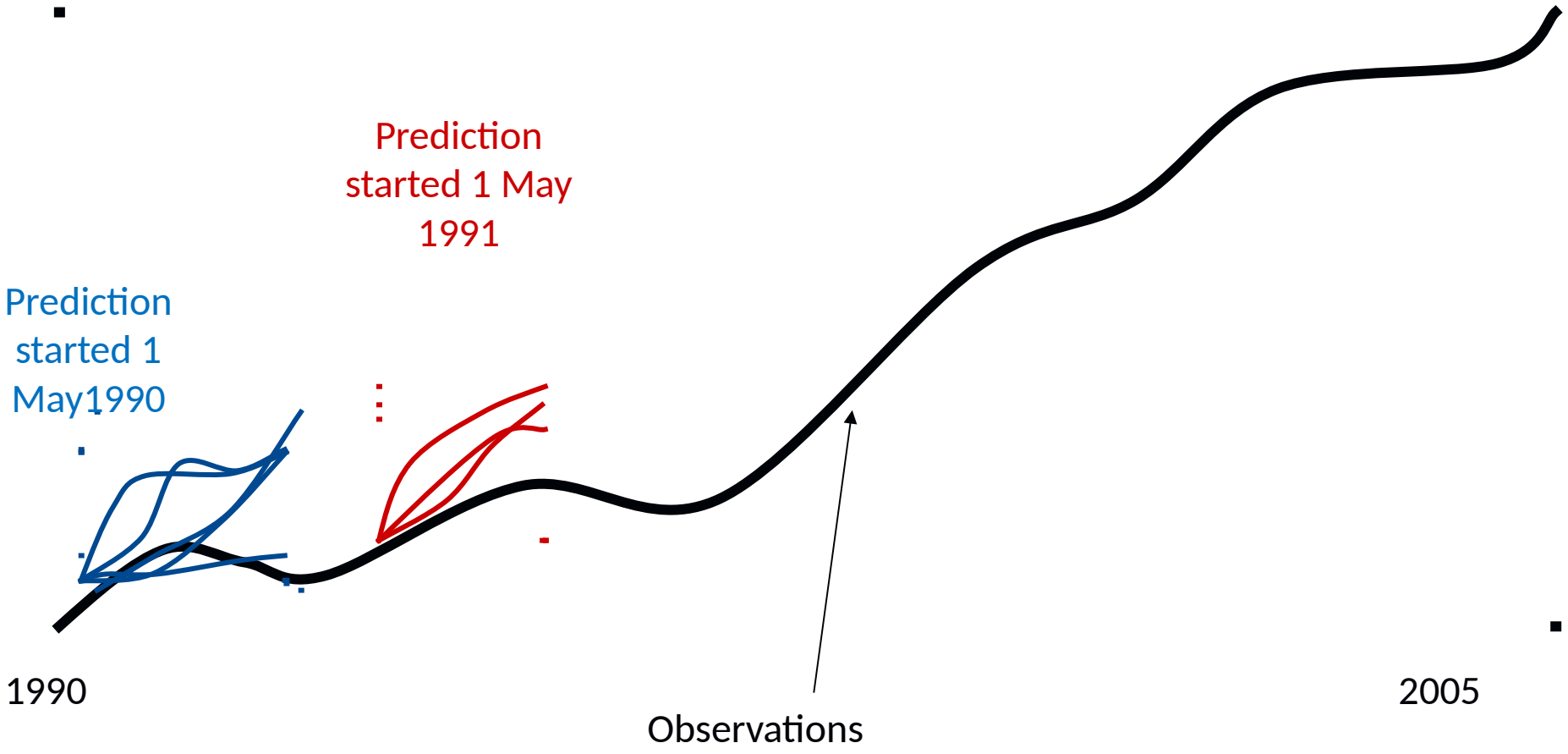
Climate predictability

- Memory on interannual to centennial timescales in the ***ocean***
- Memory on seasonal to interannual timescales in the ***sea ice*** and ***land surface***
- ***External radiative forcings*** (solar activity, greenhouse gases, aerosols)

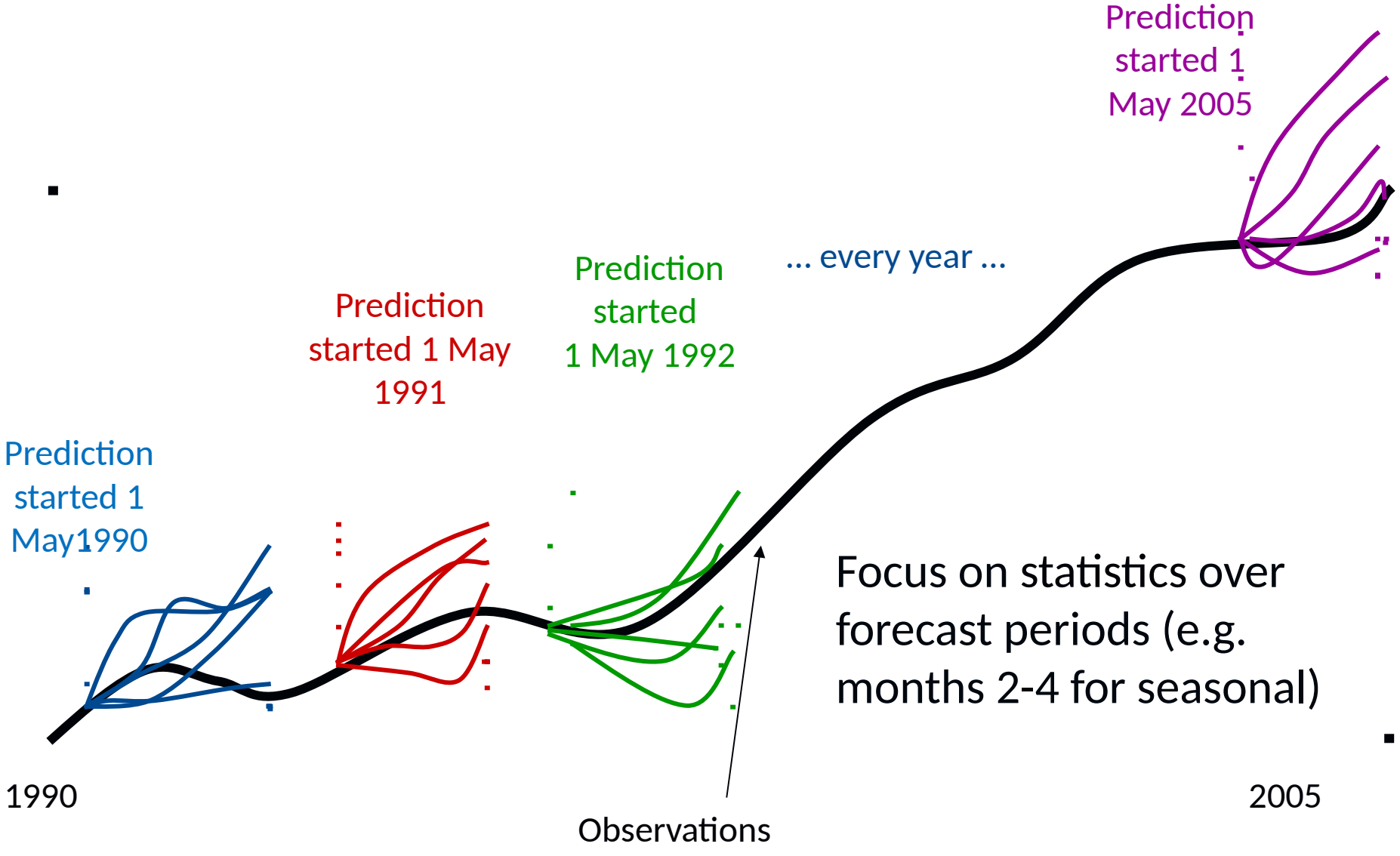
Climate prediction hindcasts



Climate prediction hindcasts



Climate prediction hindcasts



Running climate predictions

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Climate prediction allows running jobs independently and simultaneously by wrapping together ensemble members for different start dates.

A workflow manager is required.

5,500 simulated years -> 1.4 PB

CMIP6 DCPP

EC-Earth3 at Lindgren, PDC						
Number of Start Dates		1	5	10	10	20
Number of Members		5	5	5	10	10
Number of Independent Simulations		1	25	50	100	200
T159-ORCA1	Cores	144	3600	7200	14400	28800
	Wall-clock Time (Hours) / year	5	5	5	5	5
	CPU Time (Hours) / year	720	18000	36000	72000	144000
	Output Size (GB) / year	10,80	480	960	1920	3840
T255-ORCA1	Cores	360	9000	18000	36000	72000
	Wall-clock Time (Hours) / year	5	5	5	5	5
	CPU Time (Hours) / year	1800	45000	90000	180000	360000
	Output Size (GB) / year	19,20	5184	10368	20736	41472
T799-ORCA025	Cores	1104	27600	55200	110400	220800
	Wall-clock Time (Hours) / year	40	40	40	40	40
	CPU Time (Hours) / year	44160	1104000	2208000	4416000	8832000
	Output Size (GB) / year	256,80	6420	12840	25680	51360

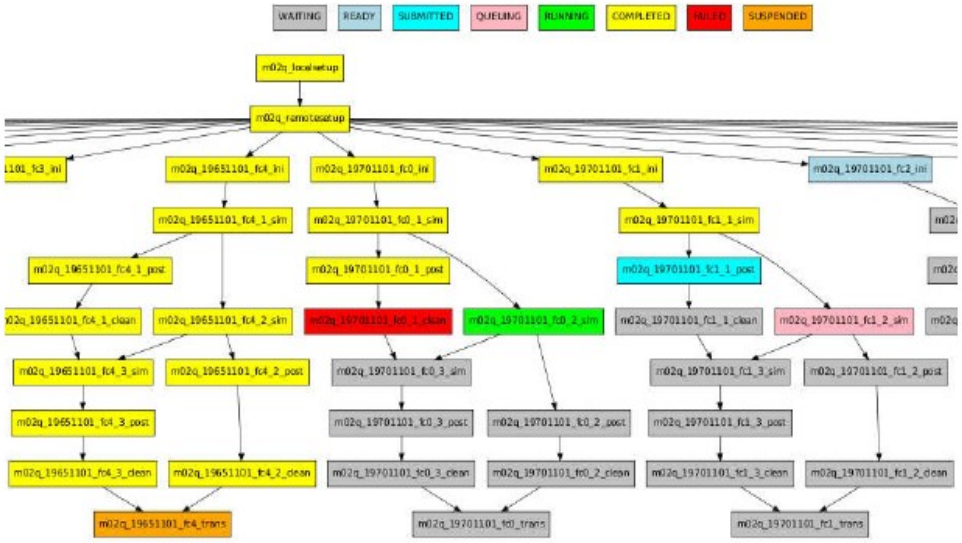
Workflow management - Autosubmit

What is Autosubmit: a python-based tool to create, manage and monitor experiments. It has support for experiments running in more than one HPC and for different workflow configurations

Why Autosubmit is needed:

- Automatisation: No user intervention is needed in submission to machines and dependencies between jobs.
- Data provenance: Assigns unique identifiers for each experiment, model version, experiment configuration etc.
- Failure tolerance: Automatic retrials in case of corrupted or missing data.
- Versatility: Runs different models in different HPC platforms

Workflow of an experiment monitored with Autosubmit:
Yellow = completed
Red = failed
Green = running
Blue = submitted
...



Domingo Manubens, Javier Vegas (BSC)

Modelling framework

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EC-EARTH

Standard resolution T255ORCA1
~ 80 km atmosphere
~ 100 km ocean

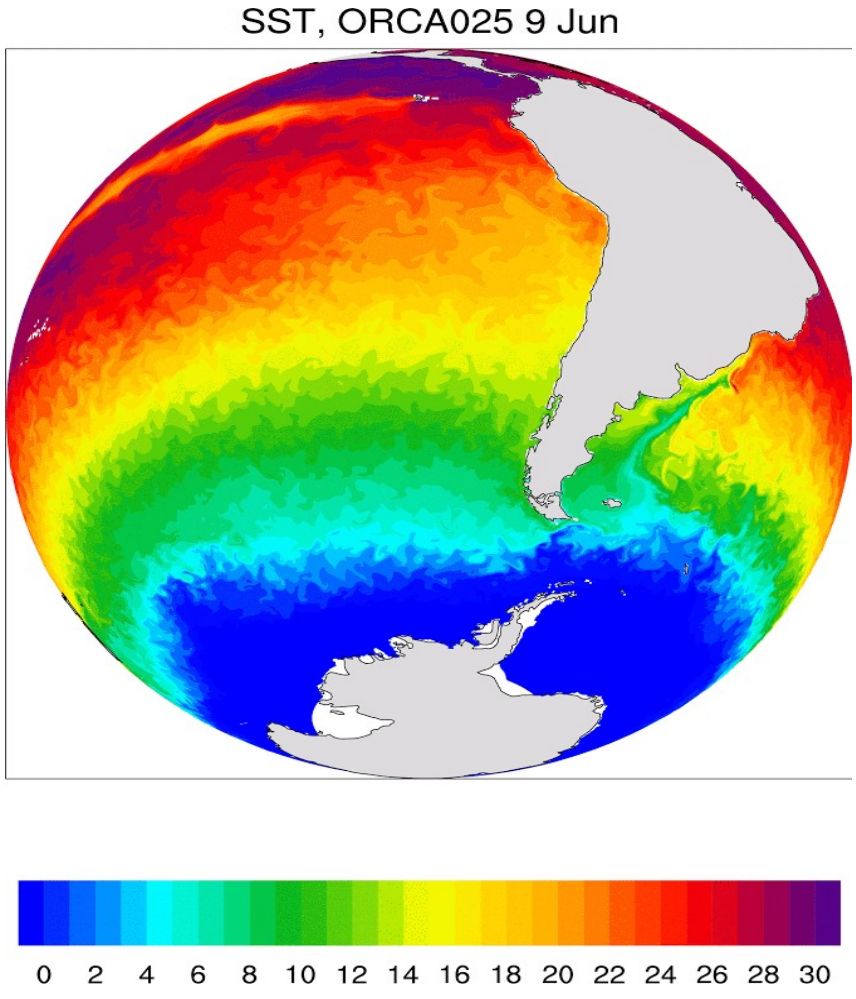
High-resolution T511ORCA0.25
~ 40 km atmosphere
~ 25 km ocean

Now testing T1279ORCA0.12
~ 16 km atmosphere
~ 12 km ocean

High-resolution forecasting

In high resolution more ocean dynamics are resolved

Sea surface temperature field
in a high resolution run



High-resolution forecasting

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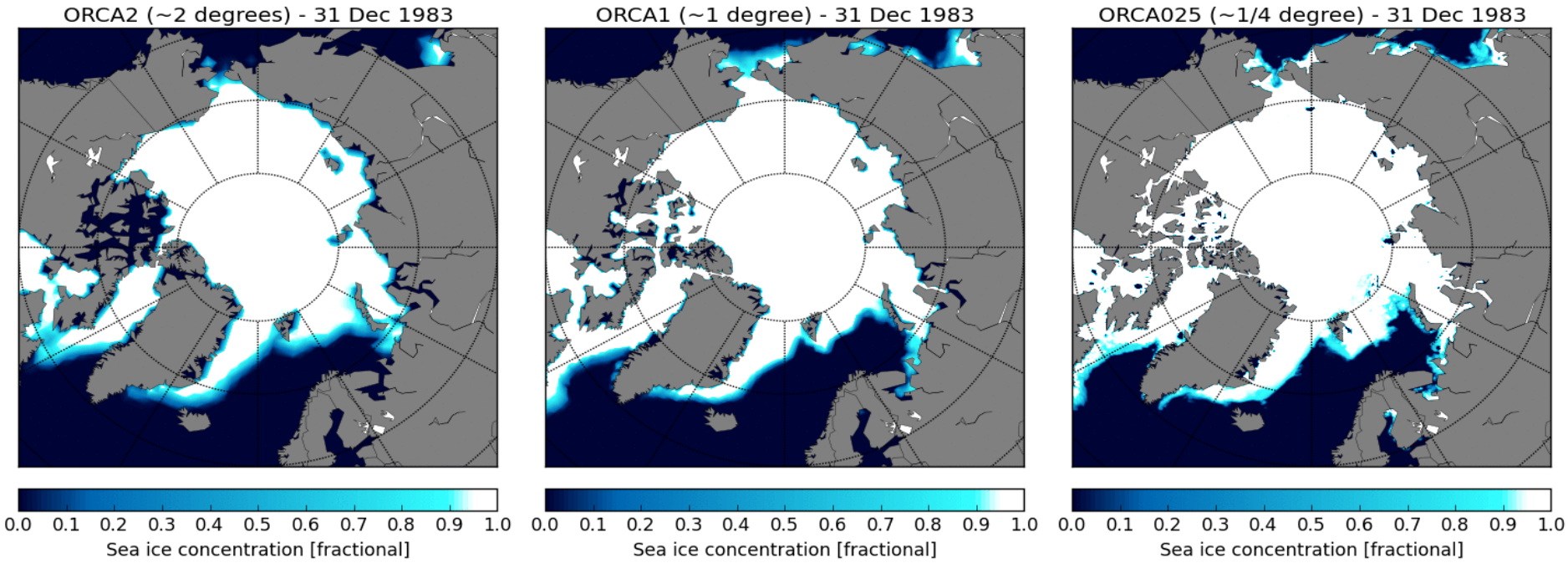
In high resolution smaller-scale processes in sea ice edges and in marginal seas are better represented

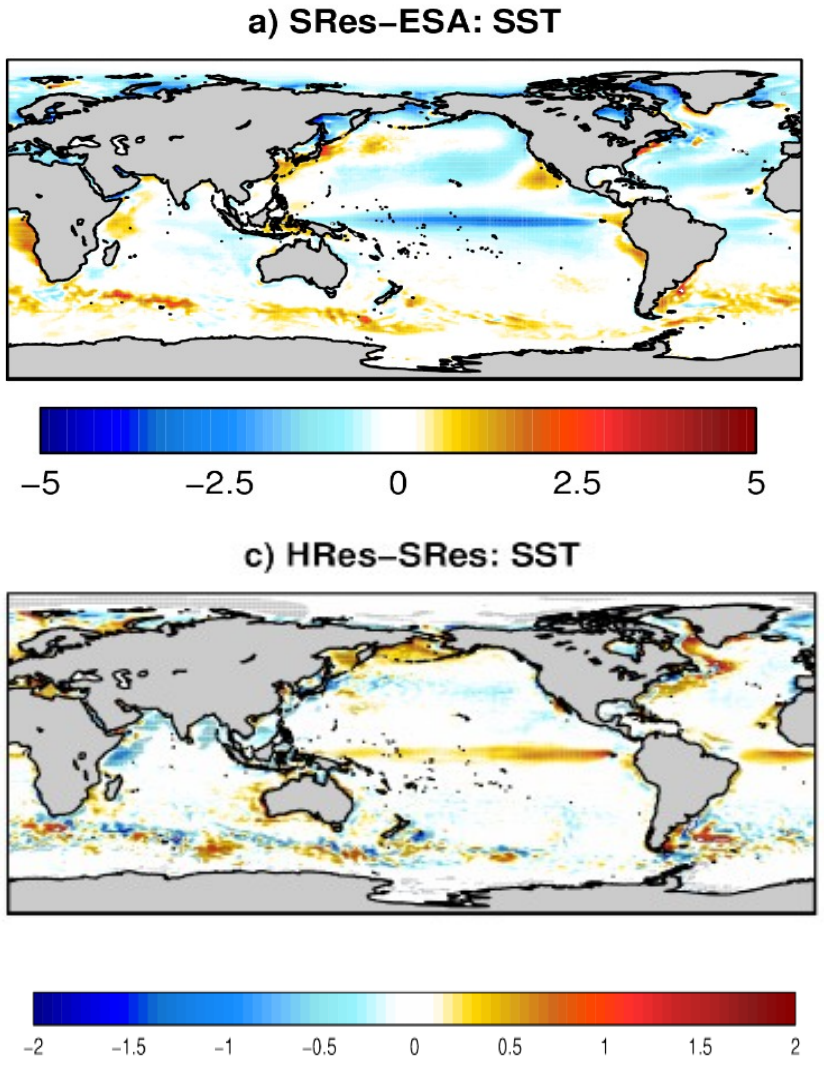


December sea ice concentration (fractional) for three different horizontal resolutions

High-resolution forecasting

In high resolution model biases in sea surface temperature are reduced

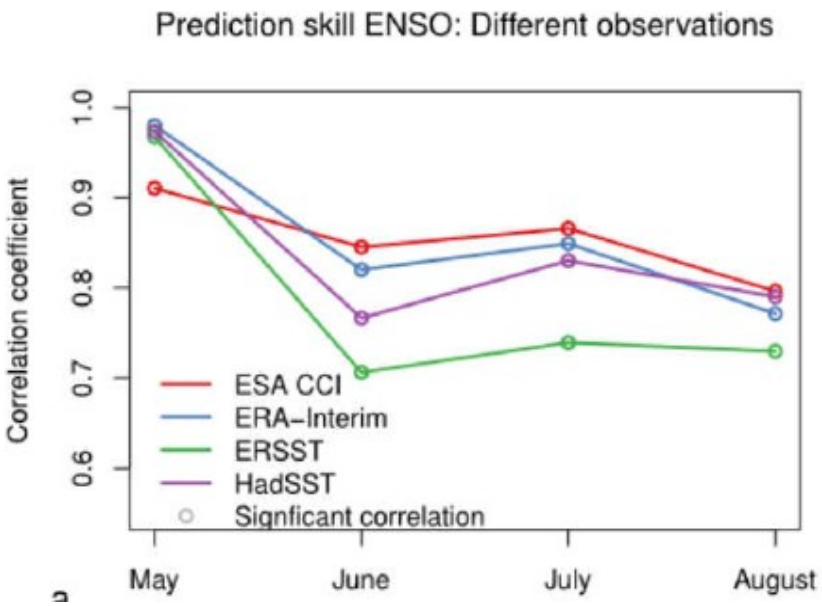
Mean model biases in sea surface temperatures in June-July- August with respect to ESA in the standard resolution experiment (top). Differences in high resolution minus standard resolution temperatures (bottom).

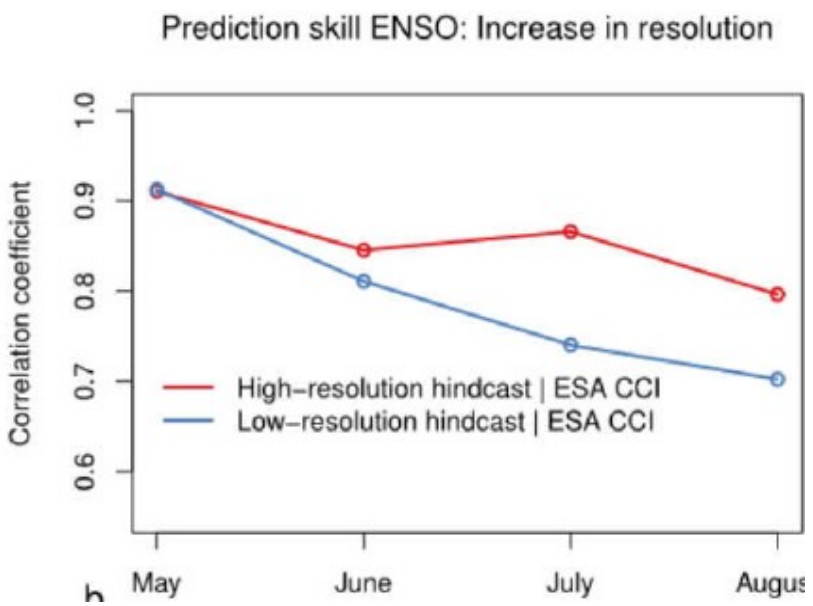


High-resolution forecasting

High horizontal resolution improves ENSO predictions.

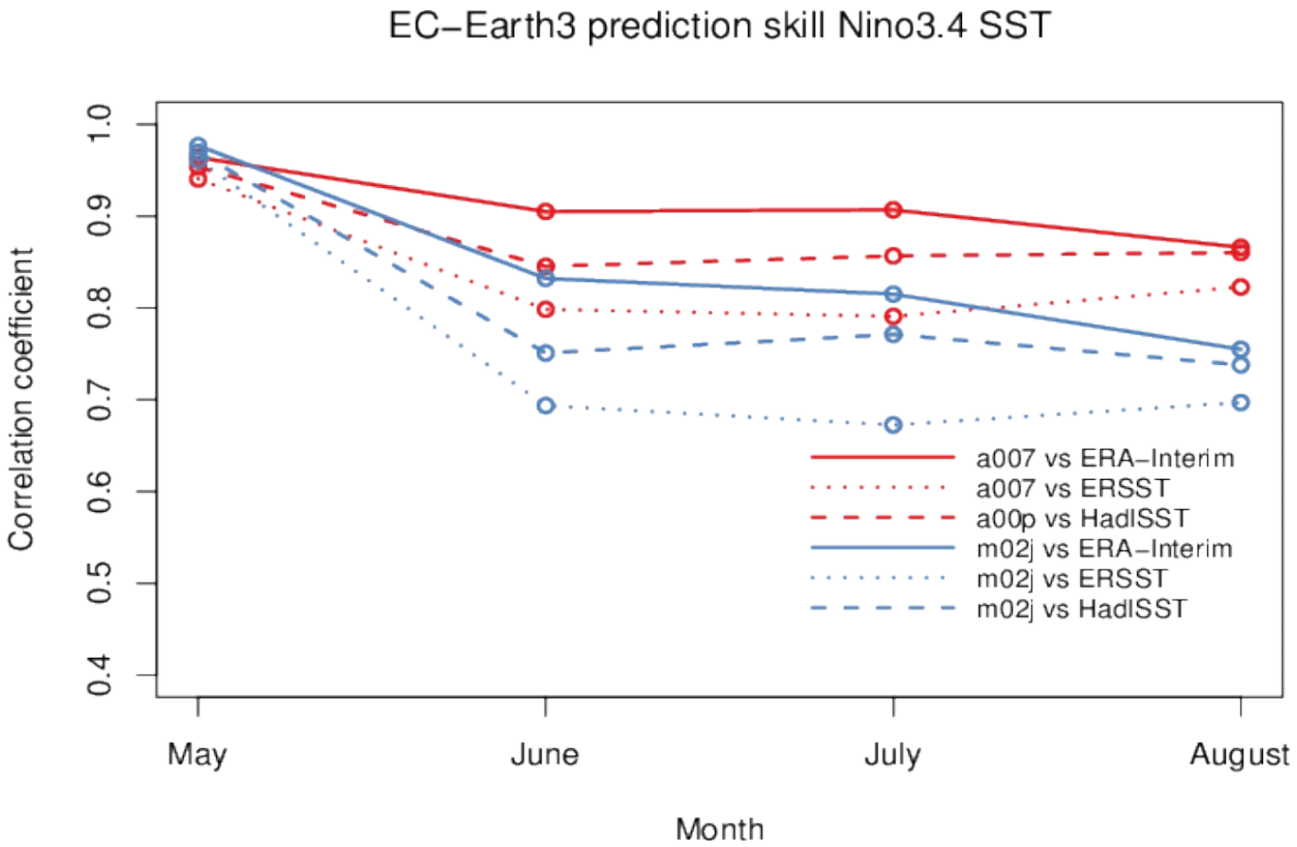
Observational uncertainty similar magnitude as improvements.





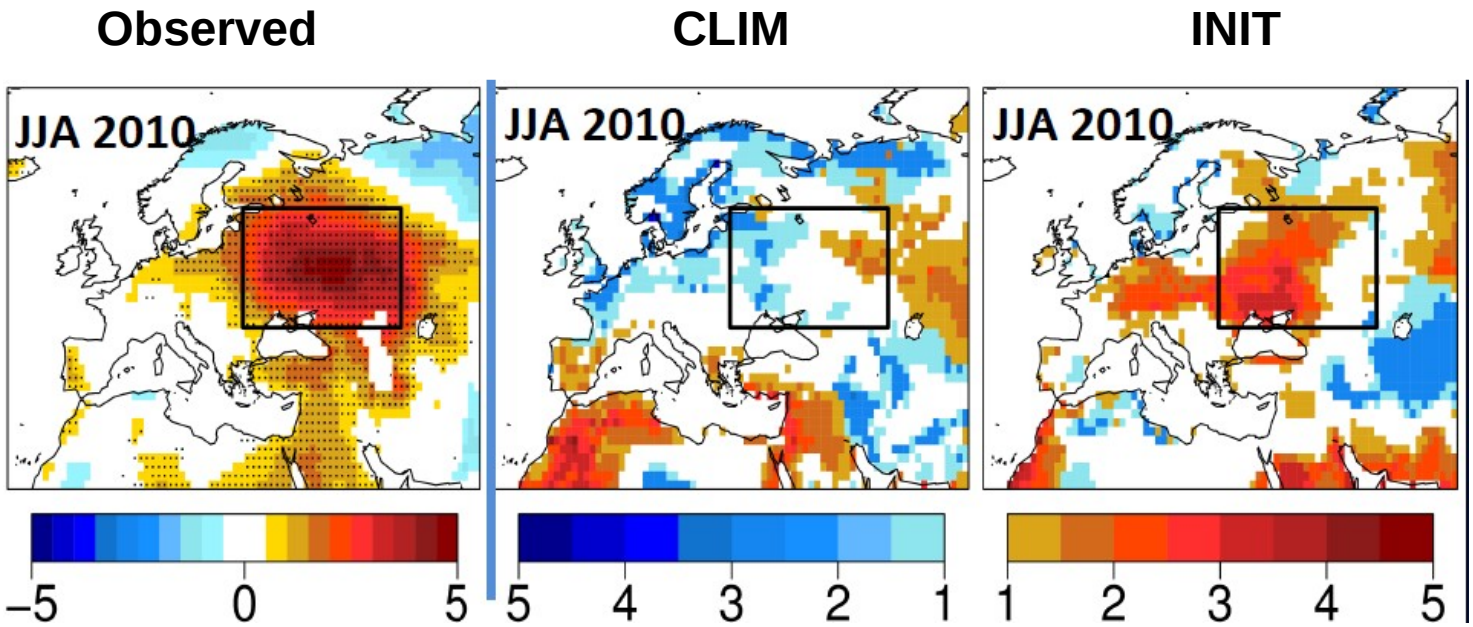
Impact of ocean initialization

Initialization from different observational estimates impacts ENSO prediction



Impact of land initialization

Seasonal prediction of Russian heat wave initializing observed land-surface (INIT) conditions and climatological (CLIM) conditions. Land-surface initialisation matters.



Summary

- Improve our forecast systems with better process representation: new parameterizations, higher resolution, better land use estimates, better use of the existing observations, better knowledge of the physical processes, etc

- Increasing model resolution allows for better representation for smaller scale processes, and better resolving of dynamics. It improves model quality and reduces model errors

- Even if more technically challenging and computationally demanding, increasing resolution is essential in future model development

- Increasing resolution is not panacea: other aspects (i.e.better ocean/land-surface initialization) also important for improving forecast quality